Subject: Evaluation of EMI with the Wiener Crate and Power Supply Prototype for the BLM Upgrade

To: File

From: Craig Drennan

Date: December 14, 2004

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I. Introduction

This memo reports the findings of our electro-magnetic interference test performed on the first Wiener crate and power supply for the BLM Upgrade. The conclusions and recommendations are presented first. Description of the tests performed and various spectrum analyzer screen shots with brief explanations are included.

The unit under test is a Wiener Plien & Baus 6U VME UEP6021 series crate and power supply. This power supply was determined to be the best candidate for a low noise switching supply because it was specified to meet the FCC class B criteria for radiated and conducted noise, and specified as having a VDC output ripple of less than 15 mV peak-peak. Similar units were previously bought for the MINOS/NUMI experiment back in 2001. When these EMI tests were performed on the prototype of the MINOS/NUMI Wiener crates noise levels were found to be out of tolerance. This crate and power supply was shipped back to the manufacturer and the problems were remedied. Wiener discovered issues with the arrangement of the modules in the power chassis. They also made changes to their standard product to include new top and bottom cover designs with smaller hex shaped perferations that provided better shielding of the offending EMI frequencies. The report on the EMI tests of the MINOS/NUMI crate is available upon request.

The main result of the tests on the new crate for the BLM upgrade are that the EMI produced by this crate and power supply is low, well within expectations.

II. Evaluation Results

The following are the evaluations made and the results.

1. Ripple on the VDC outputs was measured to be less than 12 mV peak to peak within a bandwidth of 20 MHz.
2. Conducted EMI coupled back onto the AC input power line was found to easily pass the FCC Class B requirements.
3. Radiated EMI measured at the top of the power supply enclosure was found to be present, but not excessive relative to other common sources. Noise spectrum plots of the noise from the Wiener crates as well as these other sources are presented below.

III. Description of the Conducted EMI Measurements

A Line Impedance Stabilization Network (LISN) was used in measuring the conducted noise from the Wiener prototype power supply. The LISN is used to filter AC power to the Equipment Under Test (EUT) and then via a highpass filter, pick off the conducted noise the device would be contributing to the power distribution system. The LISN output was monitored with a spectrum analyzer in the band from 9KHz to 30MHz. The schematic for the LISN is shown in Figure III.1. Figure III.2 shows the typical equipment setup for these tests.

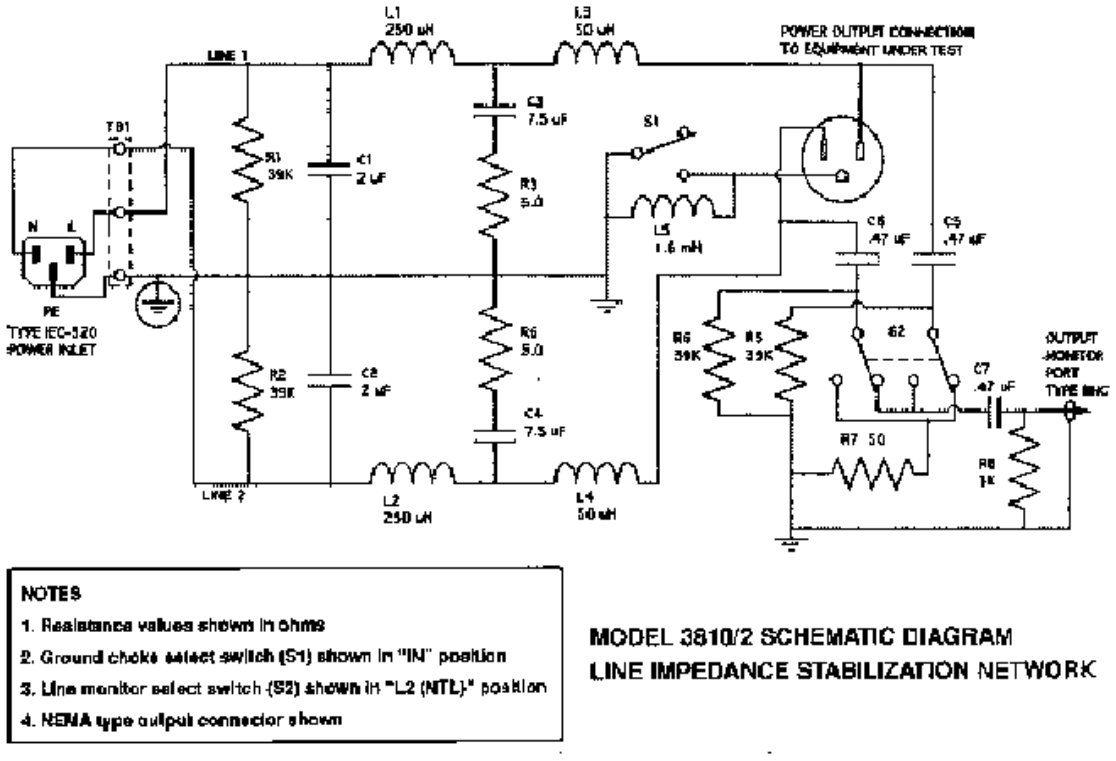


Figure III.1. Schematic of the LISN Model 3810/2 (EMCO, Austin, Texas).

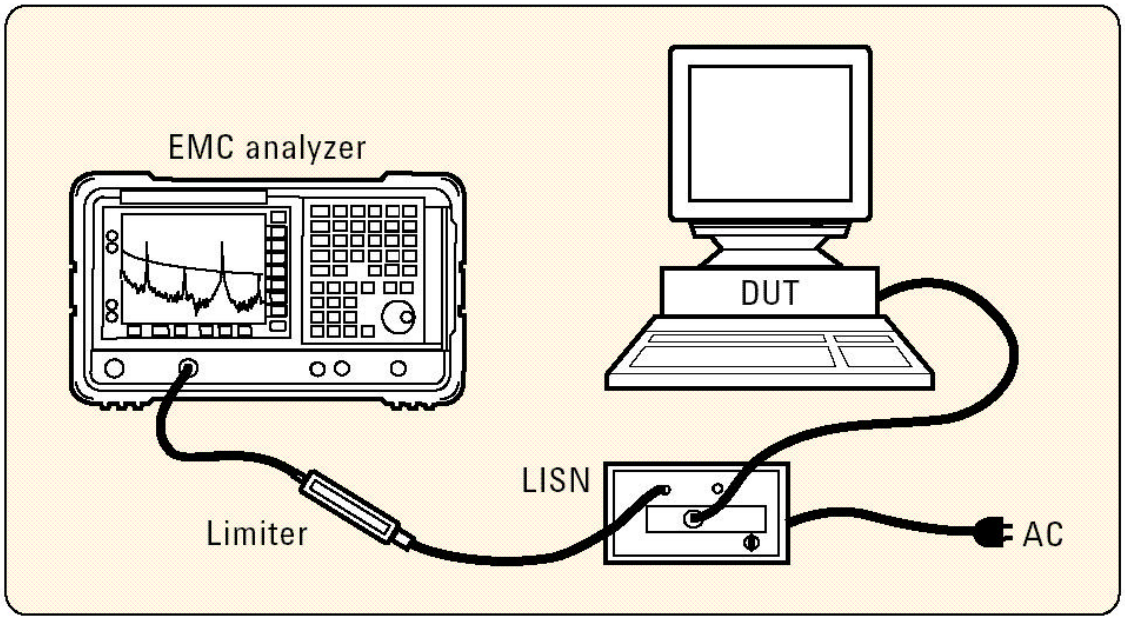


Figure III.2. Setup for the conducted EMI tests.

The limit lines shown on the plot represent those for the specification EN55022 Class B Conducted EMI limits.

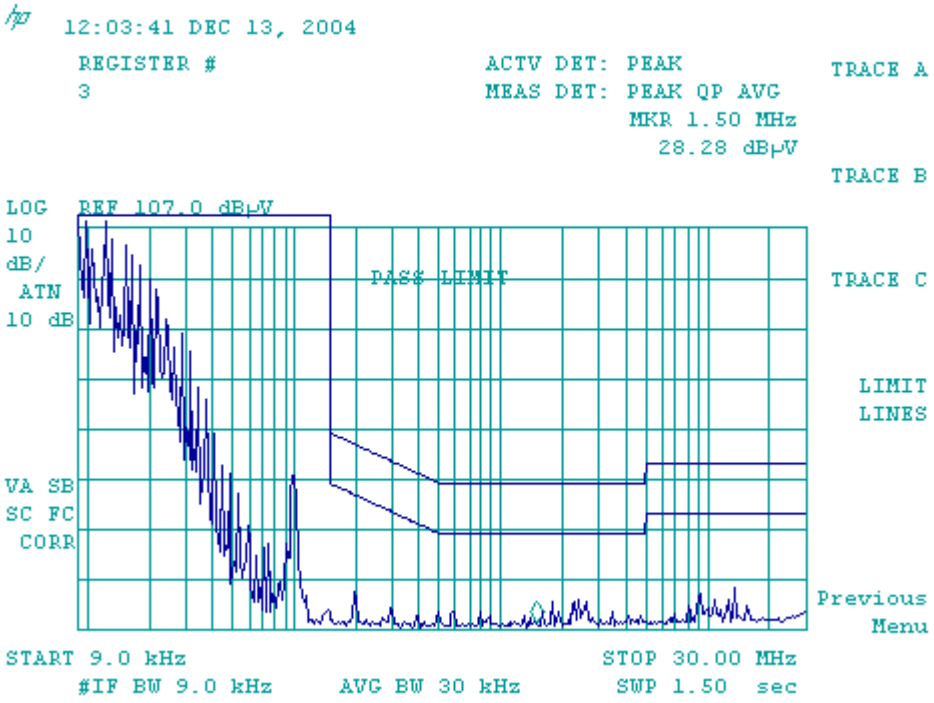


Figure III.3 Measured EMI from Wiener supply with load of 11 Amp /+5VDC, 0.6 Amp / +12VDC and 0.3 Amp / -12 VDC.

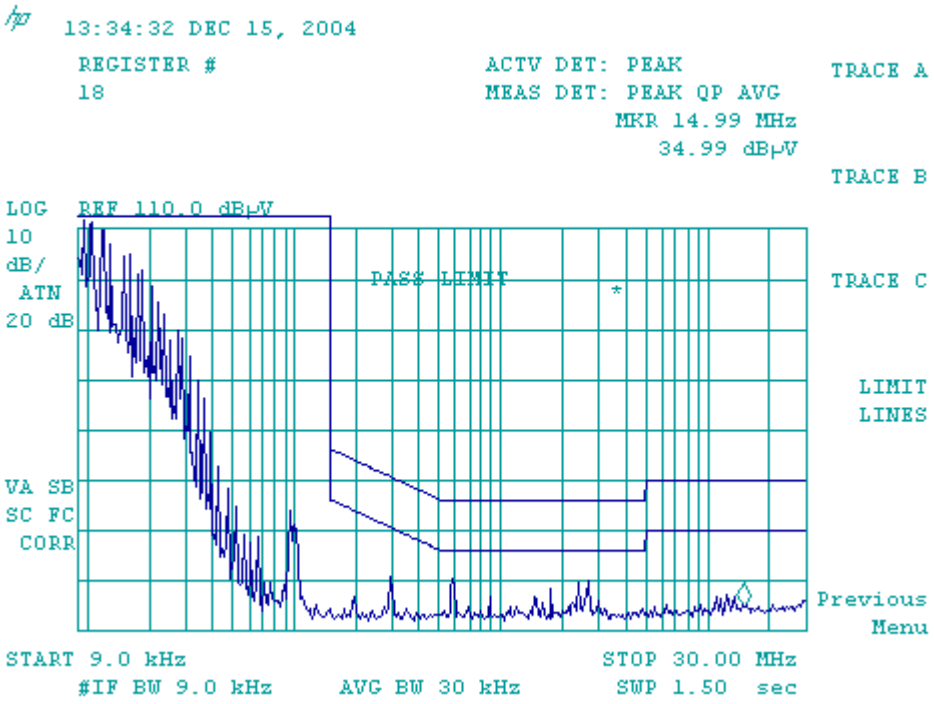


Figure III.4 Measured EMI from Wiener supply with load of 40 Amp /+5VDC.

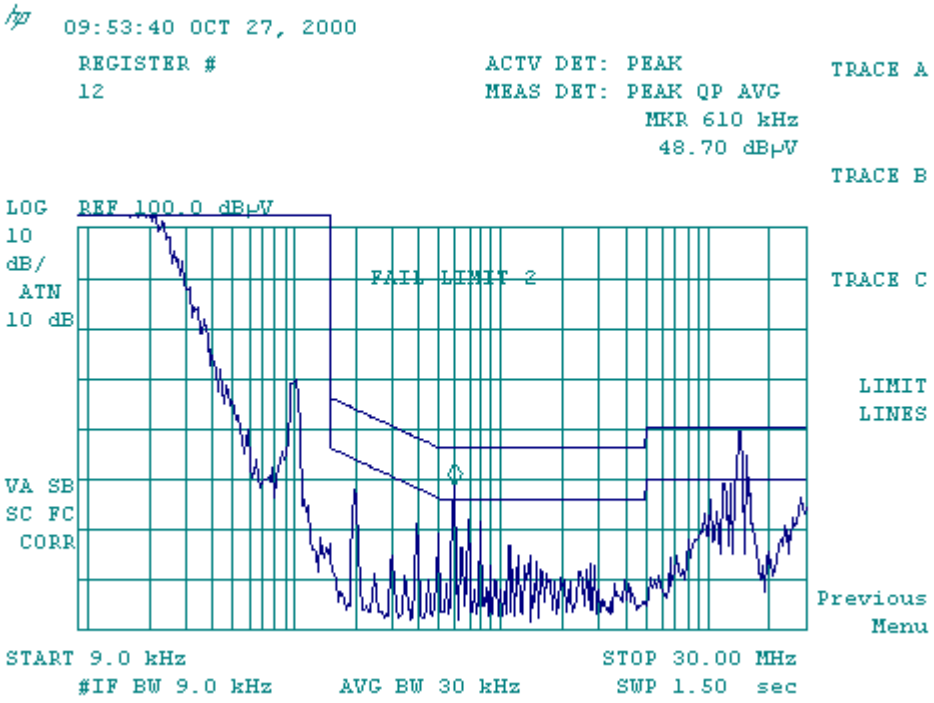
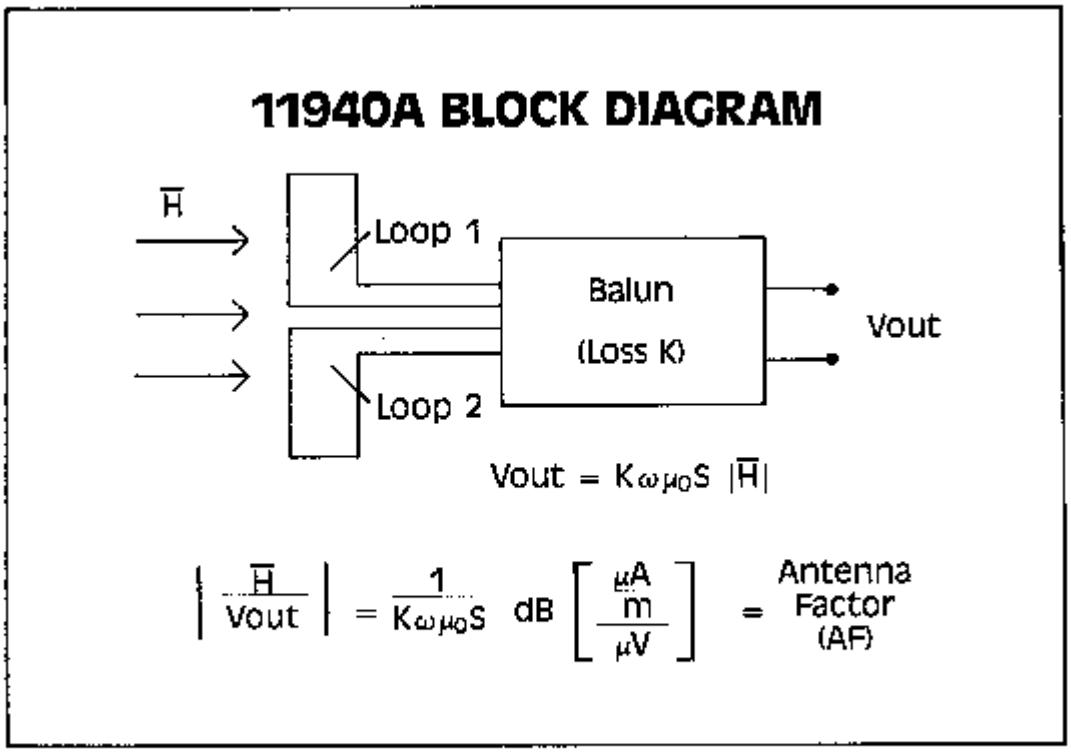


Figure III.5 Measured EMI from ASTEC with 47 Amp load on the +5VDC (reg 12).

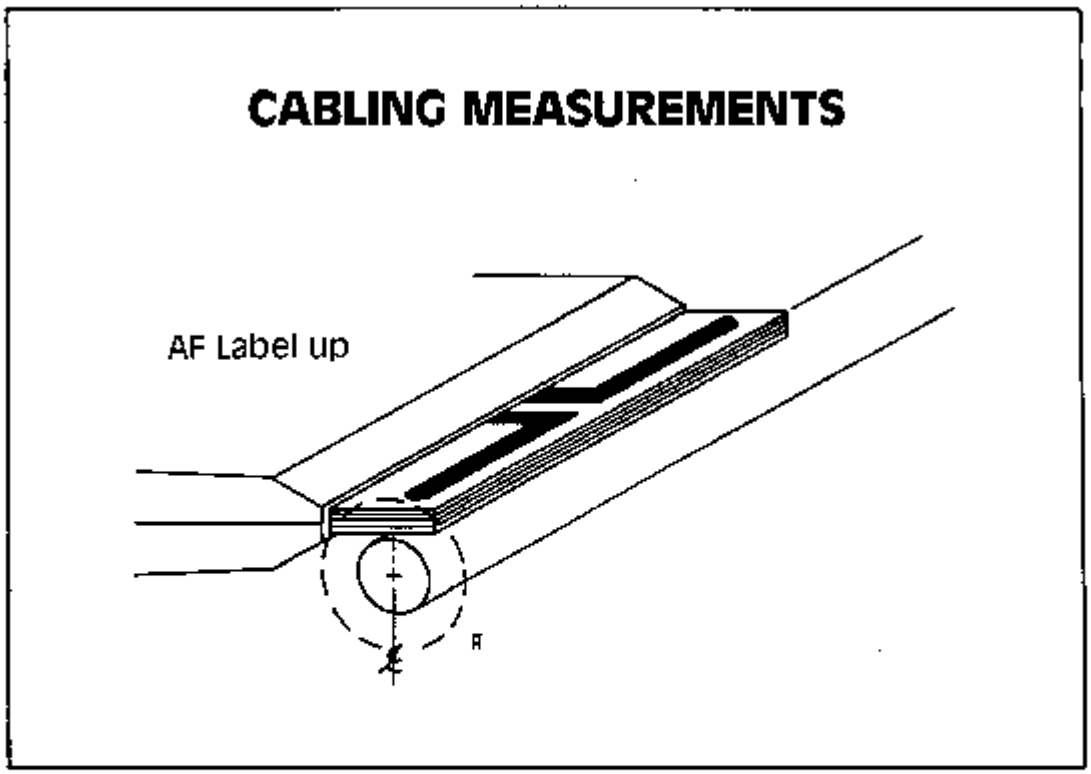
IV. Description of the Radiated EMI Measurements

The HP11940 close field probe was used as the antenna for detecting radiated noise in the vicinity of the power supply enclosure. The HP11940 close field probe is a broadband magnetic field sensor designed for EMI troubleshooting the band between 150 KHz and 30 MHz. Figure IV.1. gives a block diagram of the probe. Figure IV.2. illustrates the manner in which the probe is used to measure radiation from a cable. In a similar way, we used the probe to measure EMI at openings in the power supply enclosure.



The 11940A consists of two single turn loops feeding a balun structure. The balun structure improves the performance of the probe but introduces additional losses. These losses are taken into account in the relationship between the CW magnetic field intensity at the probe tip and the output voltage. This relationship is called the antenna factor (AF) of the probe.

Figure V.1. Block diagram of the HP11940 close field probe.



Linearly-oriented common-mode current distributions that exist on single- or multi-conductor cables have strong circumferentially-oriented magnetic field components. The loops of the 11940A should be oriented in the r-z plane to measure this field. These structures should be measured with the antenna factor label facing away from the cable under test. Slight variations in output voltage (1 to 2 dB) will be observed between the two probe orientations when measuring fields with a very high spatial gradient, due to circuitry differences on each side of the 11940A. Caution should be exercised when analyzing the measurements of the close field of structures that carry both differential- and common-mode currents. The field very near the radiator contains components of both types of current: the field of the differential mode is not completely cancelled.

Figure V.2 Illustration of how the probe can be used.

Below is a summary of the spectrum analyzer screen shots that follow. In each case the spectrum analyzer was setup to retain the maximum field measured at each frequency in the band. With this Max Hold feature enabled the surface of the electronic circuits and power supplies were scanned using various orientations of the probe. Along with the radiated EMI measurements made on the Wiener crate and power supply for the BLM upgrade are measurements of several other items to provide a reference.

Figure V.3. Baseline for the Wiener prototype power supply radiated EMI measurement.

Figure V.4. EMI above power supply module at the AC input, behind crate slot #1, power on, no load.

Figure V.5. EMI above power supply module at the AC input, behind crate slot #10.

Figure V.6. EMI above power supply module at the AC input, behind crate slot #16.

Figure V.7. EMI above power supply module at the AC input, behind crate slot #21.

Figure V.8. EMI at the Ethernet, RS232, and CANBus ports on the front of the Fan Unit.

Figure V.9. EMI seen in a scan of the top of the BLM Digitizer module.

Figure V.10. EMI seen in a scan of the bottom of the BLM Digitizer module.

Figure V.11. Excessive EMI measured in 2000 at the top surface of the Wiener prototype power supply for MINOS/NUMI before modification.

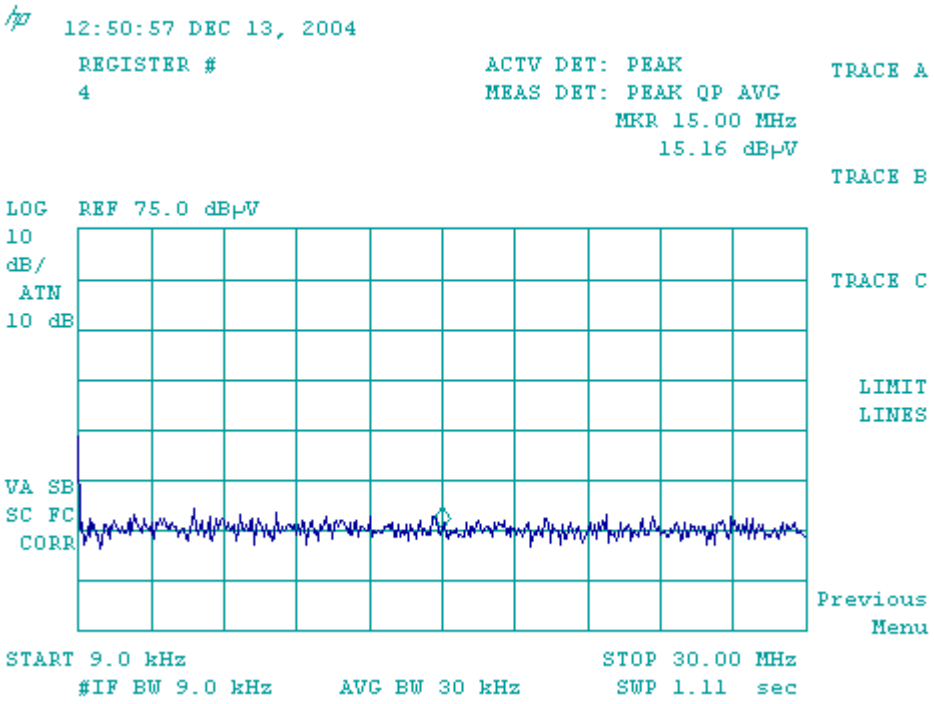
Figure V.12. Top surface of the Wiener MINOS/NUMI prototype with added shielding (sheet metal with 1/8" holes on 3/8" centers).

Figure V.13. Radiated noise from an MVME162 crate processor board.

Figure V.14. Radiated noise from a CDF TestClock V4 board.

Figure V.15. Radiated noise from a CDF Shower Max Crate Controller board.

Figure V.16. Radiated noise from an ASTEC # VS3-D2-G33-00 power supply.



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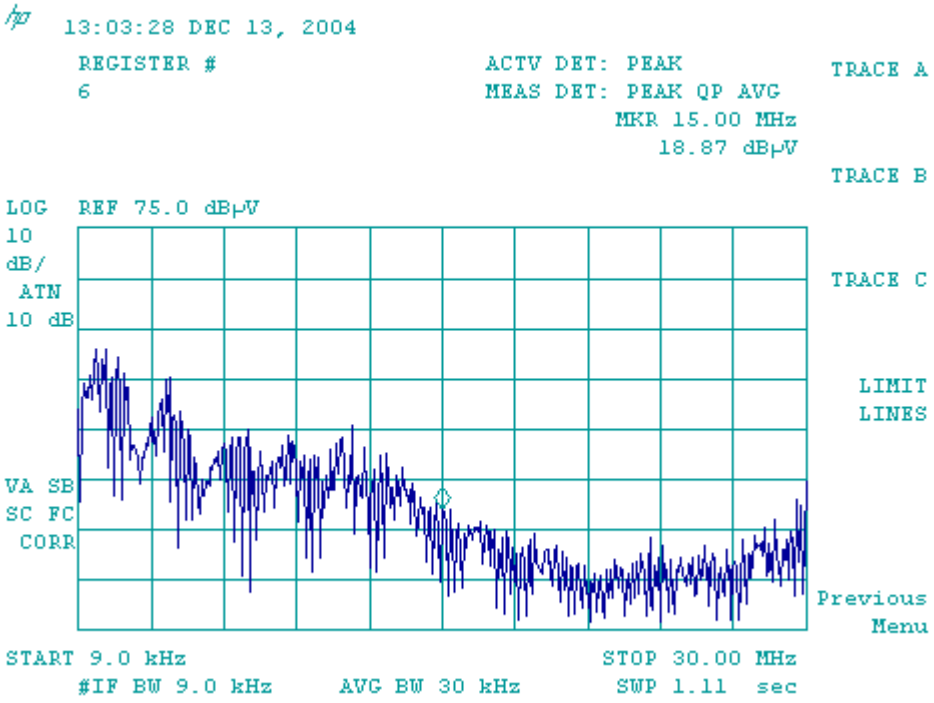

Figure V.4. EMI above power supply module at the AC input, behind crate slot #1, power on, no load.

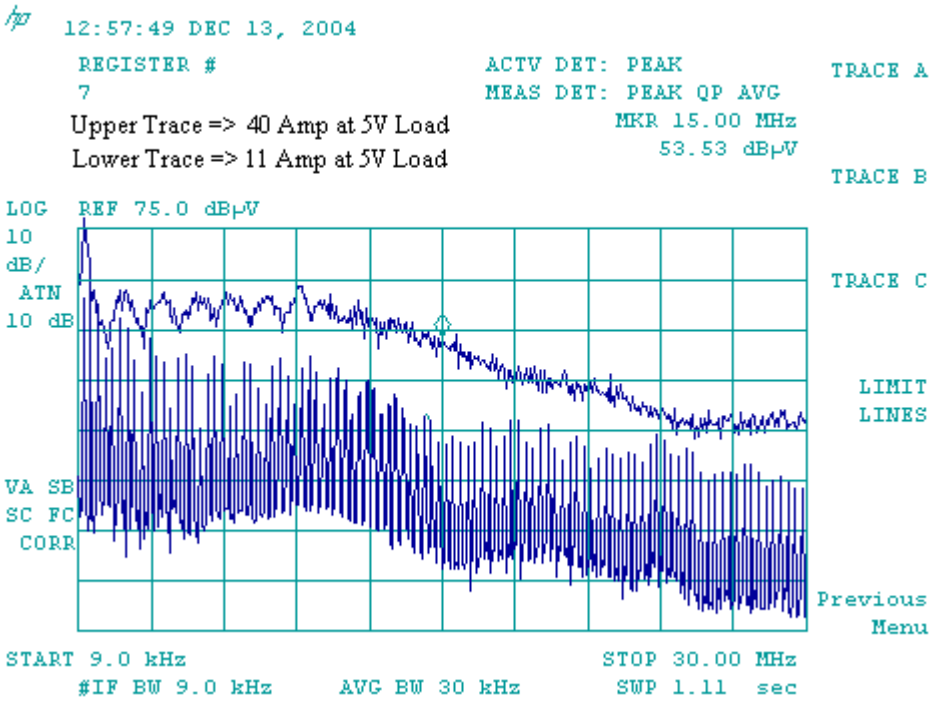

Figure V.5. EMI above power supply module at the AC input, behind crate slot #10.

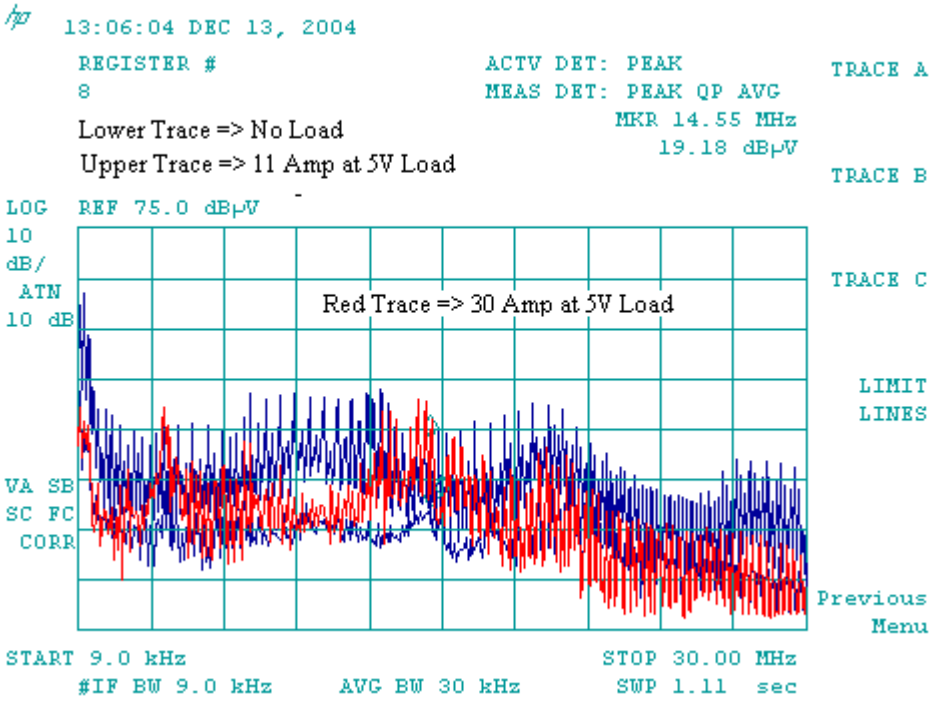

Figure V.6. EMI above power supply module at the AC input, behind crate slot #16.

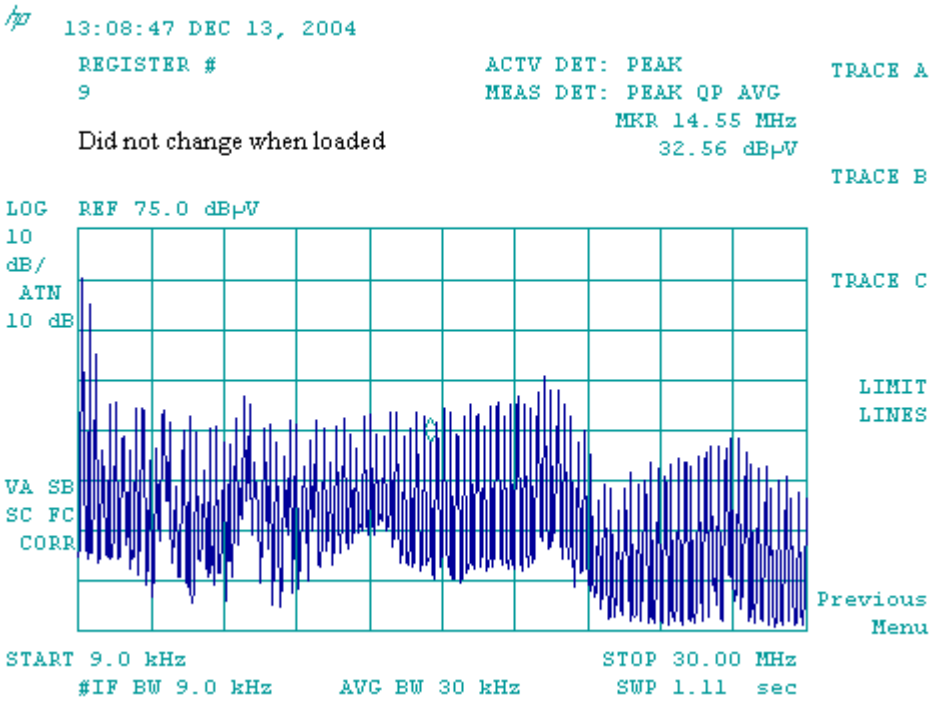

Figure V.7. EMI above power supply module at the AC input, behind crate slot #21.

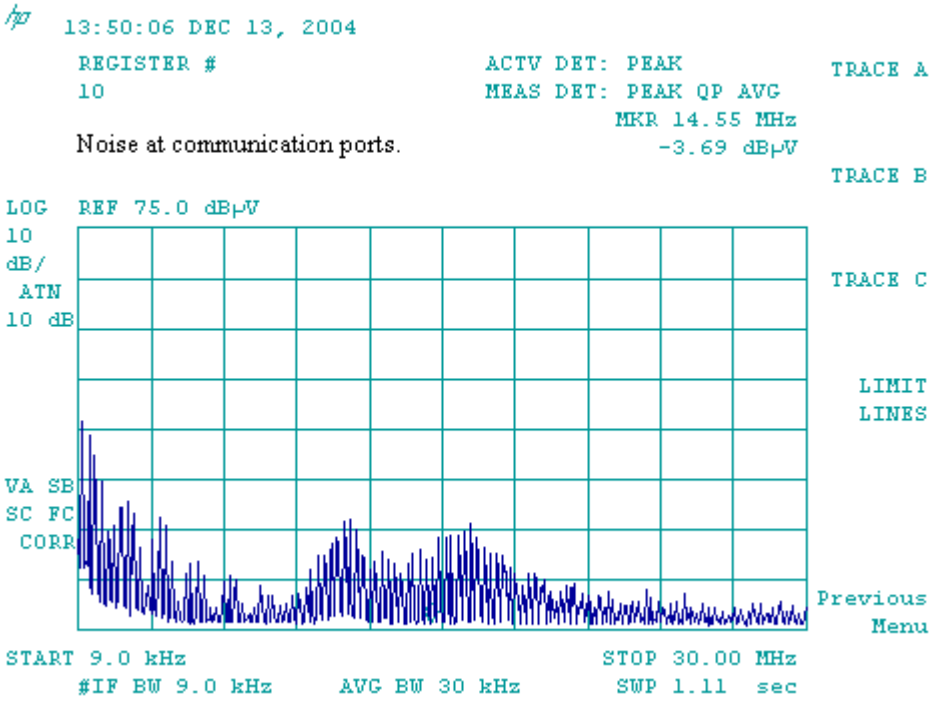

Figure V.8. EMI at the Ethernet, RS232, and CANBus ports on the front of the Fan Unit.

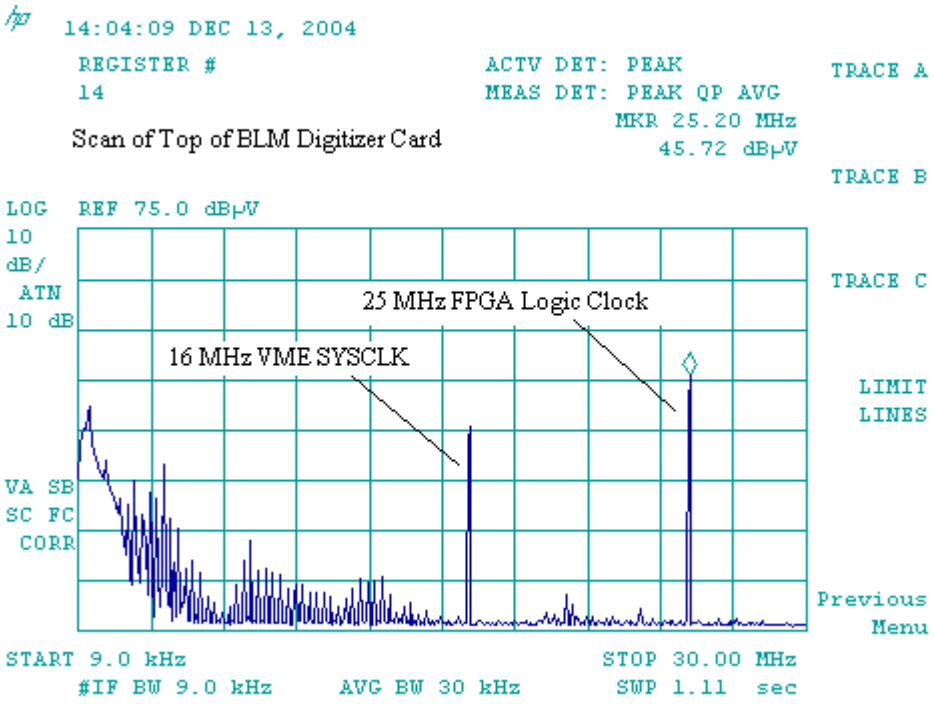

Figure V.9. EMI seen in a scan of the top of the BLM Digitizer module.

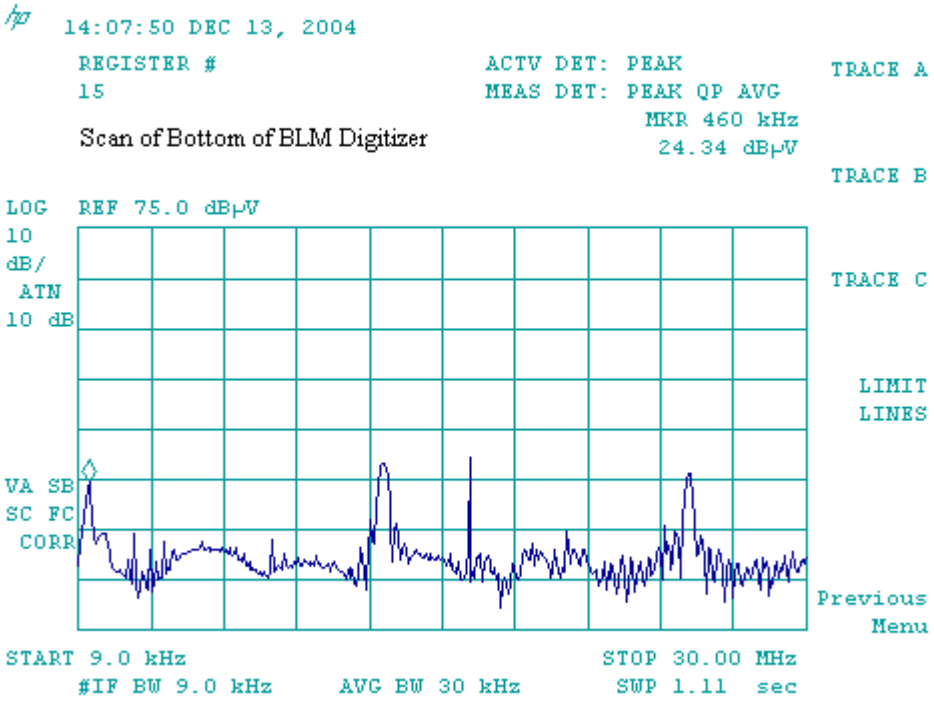

Figure V.10. EMI seen in a scan of the bottom of the BLM Digitizer module.

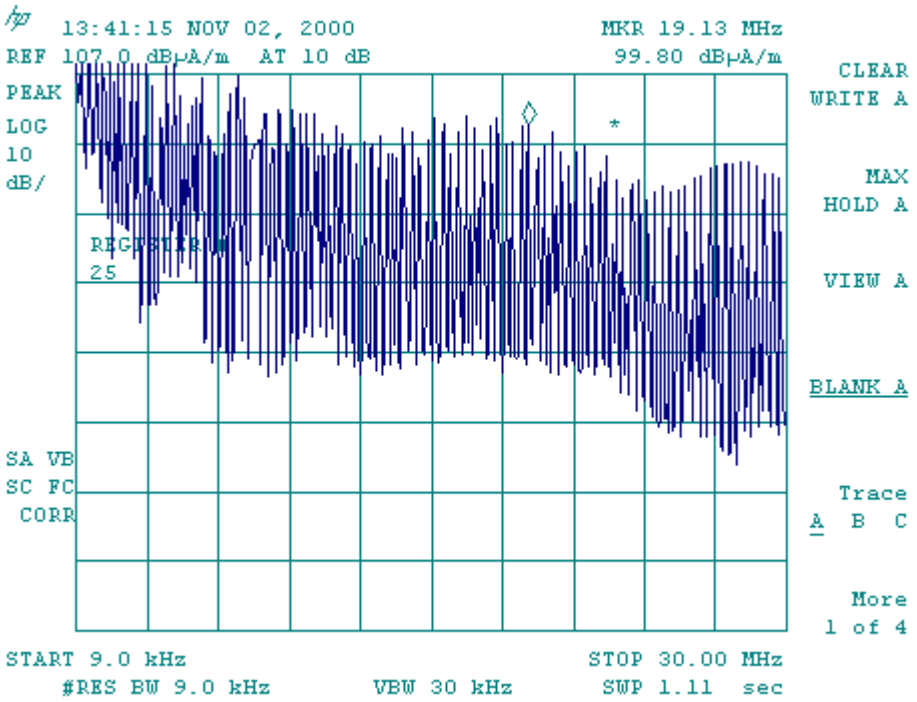

Figure V.11. Excessive EMI measured in 2000 at the top surface of the Wiener prototype power supply for MINOS/NUMI before modification.

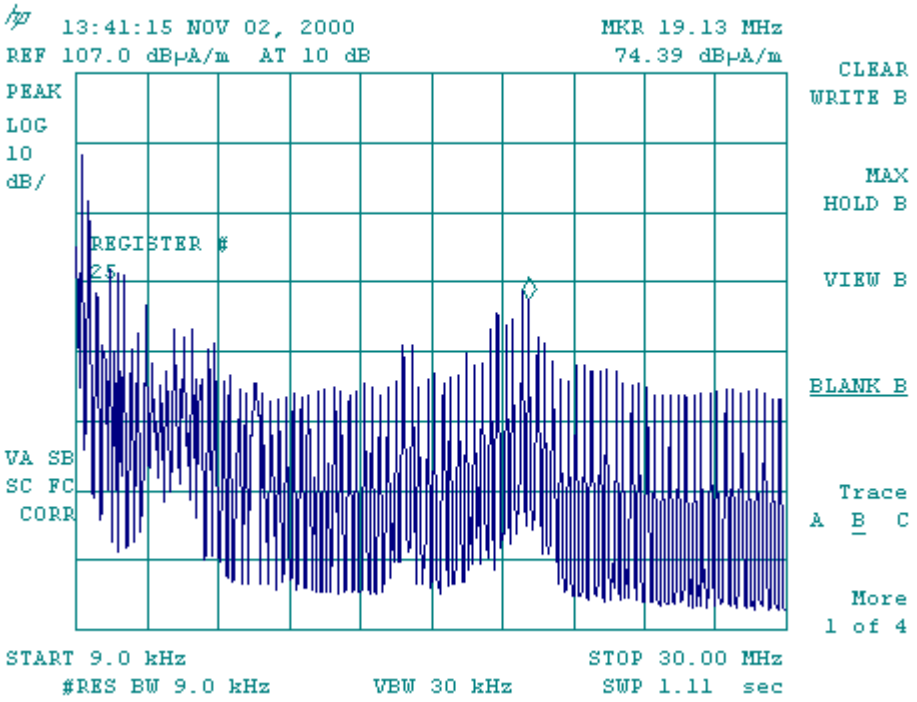

Figure V.12. Top surface of the Wiener MINOS/NUMI prototype with added shielding (sheet metal with 1/8" holes on 3/8" centers).

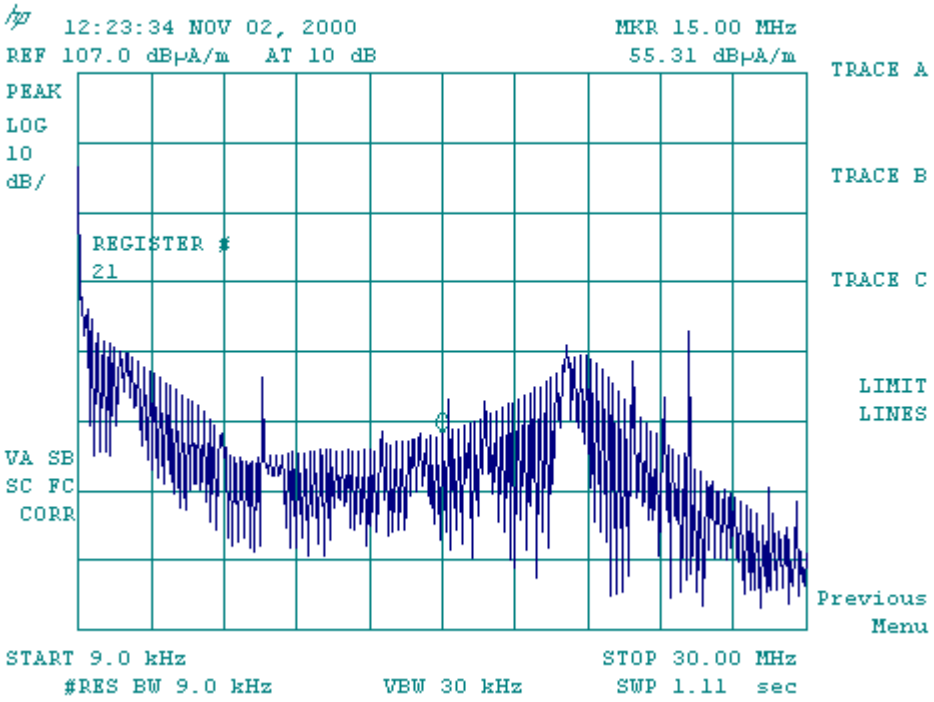

Figure V.13. Radiated noise from an MVME162 crate processor board.

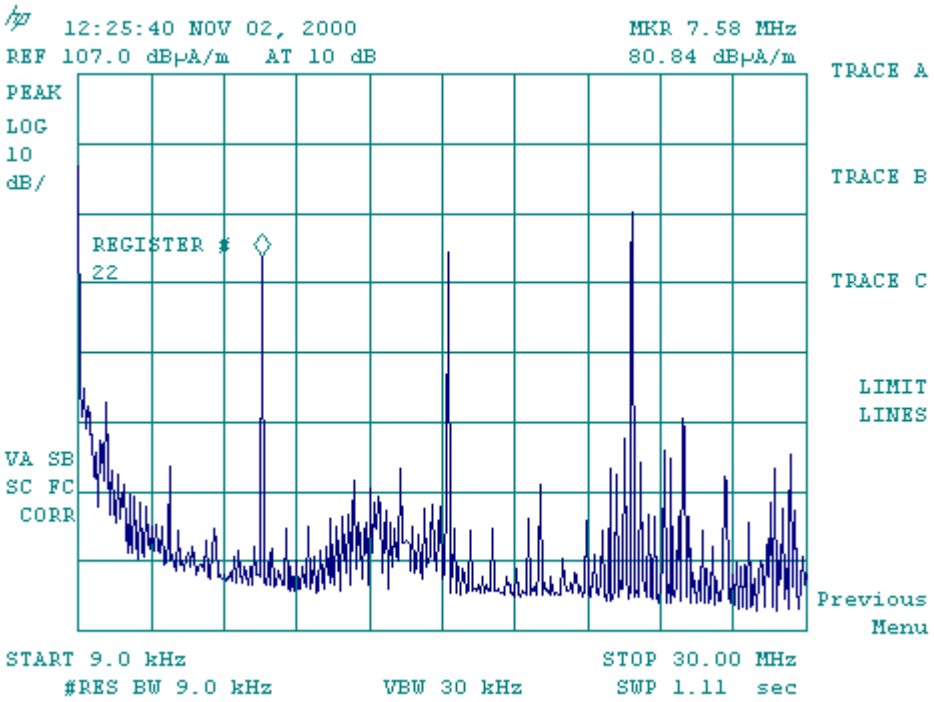

Figure V.14. Radiated noise from a CDF TestClock V4 board.

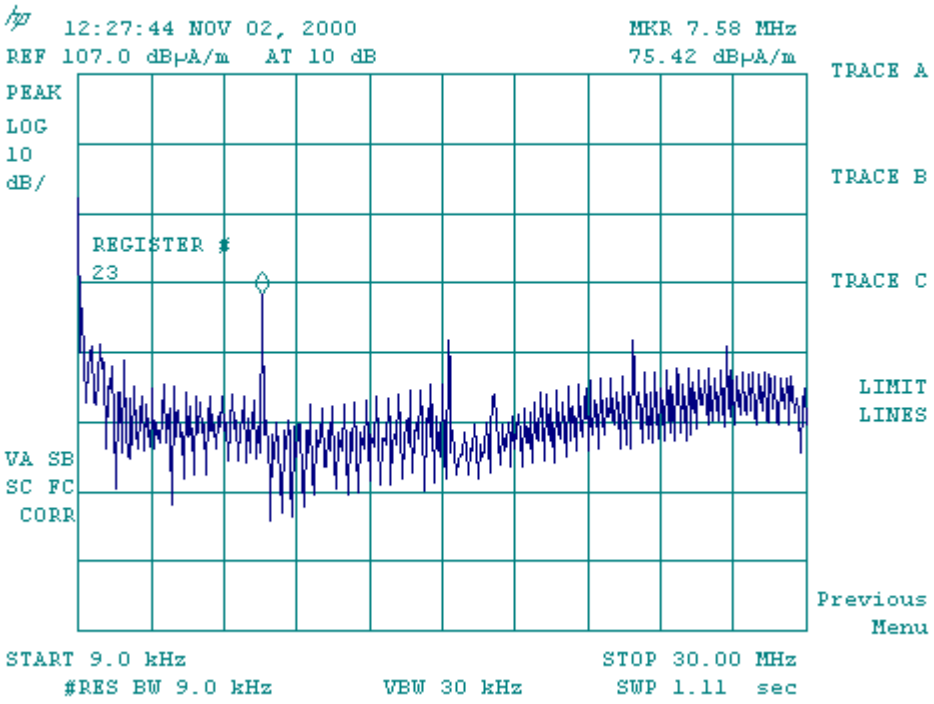

Figure V.15. Radiated noise from a CDF Shower Max Crate Controller board.

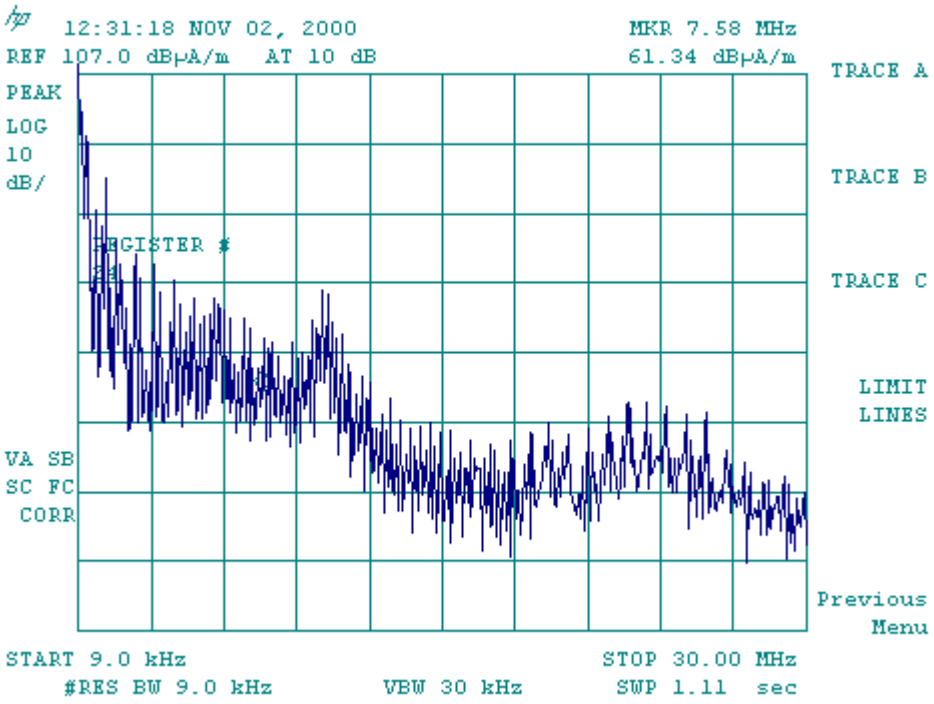

Figure V.16. Radiated noise from an ASTEC # VS3-D2-G33-00 power supply.